CONFIDENTIAL

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TO: H. C. Duecker

DATE: December 9, 1976

FROM: Julie C. Yang (2)

SUBJECT: Asbestos Fiber Counting in the Cambridge Laboratory

cc: H. A. Brown
H. A. Eschenbach
R. H. Locke
F. G. Serafin
J. W. Wolter
R. L. Oliverio/Libby
R. Geiger/Libby
J. E. Foley
J. P. Wallace
File: 71-044

SUMMARY

The reproducibility of standard fiber counts in the Cambridge laboratory was determined. Variables such as operators, equipment, and technologies were included.

It is concluded that the Cambridge laboratory showed a variation of less than 15% of the total fiber counted. The reproducibility in such a range is considered excellent compared with those described in publications (generally 40-50%).

Recent Libby lab samples were also counted in our lab and used in the study for discussion.

BACKGROUND INFORMATION

The counting has been carried out in the Cambridge laboratory by two operators, trained originally by F. G. Serafin. Facilities available for counting is a phase-contrast microscope of Bausch & Lomb, DynaZoon model; and also a TV viewing screen attachment by Techni-Quip Corp., so that an operator can either count the fibers directly with the microscope or count the fibers on the projected TV screen.

It is necessary to know the reproducibility and accuracy of our measurements in order to meet the OSHA and NESA requirements. Unfortunately, as far as we know, there is no primary standard available on the market which will allow us to check the absolute accuracy of our method. The only way we can determine whether we have reliable results is the verification of counting specific samples by several experienced personnel.

DEPOSITION EXHIBIT 4

PENGAD-Bayonne, N. J.

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Asbestos Fiber Counting
in the Cambridge Laboratory

CRITERIA

It is very difficult to decide (1) whether the fiber being counted is a true fiber even though the aspect ratio is greater than 3 to 1, (2) whether the size of fiber should be counted at all. For example, slivers of vermiculite or plates standing on edge should be avoided; the judgment is mainly based on experience and knowledge of microscopy.

Based on Field Information Memorandum #74-92 of OSHA (issued 11/21/74), the maximum diameter of a fiber to be counted is 3 μ, and the maximum length of a fiber to be counted is 30 μ. The Memorandum from MESA issued 12/13/74 is about the same except the maximum length of fiber to be counted is 25 μ.

In the Cambridge laboratory we have used the following guidelines:

1) particles must appear to be fiberous rather than as crystals or slivers,
2) the maximum diameter of a fiber to be counted is 3 microns,
3) the minimum length of a fiber to be counted is 5 microns,
4) the maximum length of a fiber to be counted is 30 microns,
5) the length to width ratio must be 3 or more to 1.
6) the separate or individual fibers must contain fibrils; a fibril cannot be subdivided and would be counted as one if it meets the other criteria.
7) The basic number of fields to be counted is 50, and if no fibers or only one fiber is found in counting the first ten fields, then 100 fields should be counted.

EXPERIMENTAL DATA

All the counting data are presented in Tables 1 to 6. In these tables the average variations in % are calculated and presented.

Table 1. Effect of different viewing equipment with the same operator.
Table 2. Effect of same viewing equipment with different operators:
(a) Microscope (b) TV screen
Table 3. Effect of the same viewing equipment and the same operator.
Table 4. Summarized results of Tables 1, 2, and 3.
Table 5. Statistical study of Cambridge results on counting samples from the Libby lab.
Table 6. Comparison of the results from Libby laboratory and Cambridge laboratory.

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Asbestos Fiber Counting
in the Cambridge Laboratory

DISCUSSION

Regardless of the variables employed, the Cambridge laboratory showed less than 15% variability in the counting data, and the average standard deviation of 20 samples is 0.18 fiber per cc.

According to a few papers published in this area (Ref. 1 and 2), the standard deviation of the results varied between 0.4 - 1.2 f/cc, under the field conditions, and 0.2 f/cc under ideal laboratory conditions. Another paper cited the coefficient of variation to be about ± 20%, and the maximum can be ± 50%. Based on these results, the Cambridge data looked very respectable.

In verifying the Libby data as shown in Table 6, the Libby counting results are consistently higher (in fact, about 2X) than the Cambridge results. (H. Eschenbach and F. Serafin counted 5 samples and their results are in-between, but closer to the lower values of the Cambridge lab.)

It is possible that the two laboratories are using different criteria to identify the fiber or select the fibers for counting. The more likely explanation of the difference is because the filter Cambridge received were the ones Libby had cut a section off of, for evaluation. In this operation, the filter surface has been disturbed and some fibers may have fallen off resulting in lower fiber values. However, another factor is that in this group of samples (from Libby lab) the range of fiber length was very large, wider than usual; there were many fibers much greater than 30 μ and also many less than 5 μ, but close to 5 μ size. In our procedure these should not be counted.

RECOMMENDATION

To check the discrepancies between Libby and Cambridge laboratories, the following actions are recommended:

1) The Cambridge-prepared slides of Libby samples from T&A 49930 will be sent back to Libby for counting.
2) A second set of Cambridge-prepared slides (T&A 49561-2 samples from Portland, Oregon) will be sent also to Libby for counting. This group has very different fiber length distributions and fiber density than the group from Libby.
3) Libby-laboratory-prepared slides of T&A 49930 will be sent to Cambridge for counting.

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4) The Libby samples (in casettes) for T&A 49930 will be sent back to Libby for re-evaluation, which would show the effect of transportation and filter handling on counting.

5) After all the counting results are compiled, decisions will be made on how to equalize our results.

6) In addition, the calibration factors for both laboratories will be rechecked.

REFERENCES

1. Ortiz, L.W.; Ettinger, H.J.; and Fairchild, C.I., "Calibration Standards for Counting Asbestos" J. Am. Ind. Hygiene Assoc. pp. 104-111 (Feb. 1975)

2. Rajhans, G.S.; and Bragg, G.M. "A Statistical Analysis of Asbestos Fiber Counting in the Laboratory & Industrial Environment" J. Am. Ind. Hygiene Assoc. pp. 909-915 (Dec. 1975)

3. General:

   a. Memorandum MESA 12/13/74

   b. Field Information Memorandum OSHA #74-92 11/21/74

   c. Procedure for Fiber Counting by F. G. Serafin 2/23/76

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attachments

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TABLE I

EFFECT OF DIFFERENT VIEWING EQUIPMENT ON REPRODUCIBILITY OF COUNTING BY A SINGLE OPERATOR

(Reference: T&A 49561-2 Operator: J. Foley)

A)

Sample No.	TV	Microscope	MEAN ($\bar{X}$)	VARIATION $\lvert Xi - \bar{X} \rvert$	VARIABILITY %
1	4.31	3.8	4.055	0.255	6.29
2.	0.11	< 0.11	0.11	0	0
3.	0.68	1.20	0.94	0.26	27.66
4.	2.17	2.62	2.395	0.225	9.39
5.	3.48	3.76	3.62	0.14	3.87
6.	1.82	1.94	1.88	0.06	3.19
7.	0.17	0.17	0.17	0	0
8.	4.72	3.75	4.235	0.485	11.45
9.	0.14	0.29	0.215	0.075	34.88
10.	0.04	0.04	0.04	0	0
11.	1.51	0.88	1.195	0.35	26.36
				av:	11.19%

(Reference: T&A 49431 Operator: J.P.Wallace)

B)

Sample No.	TV	Microscope	($\bar{X}$)	$\lvert Xi - \bar{X} \rvert$	%
1.	2.64	4.08	3.36	0.72	21.43
2.	2.53	3.29	2.91	0.38	13.06
3.	2.61	3.25	2.93	0.32	10.92
4.	3.42	4.10	3.76	0.34	9.04
5.	5.24	3.87	4.555	0.685	15.04
6.	3.19	2.96	3.075	0.115	3.74
7.	2.28	2.10	2.19	0.09	4.10
8.	2.61	3.69	3.15	0.54	17.14
9.	3.23	3.42	3.325	0.095	2.86
10.	1.67	2.58	2.125	0.455	21.41
11.	4.20	2.91	3.555	0.645	18.14
12.	3.94	4.10	4.04	0.10	2.48
13.	1.77	4.30	3.035	1.265	41.68
				av:	13.93%

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TABLE 2

EFFECT OF DIFFERENT OPERATORS ON REPRODUCIBILITY USING THE SAME VIEWING EQUIPMENT

(Reference: T&A 49561-2)

A) Microscope Viewing

Sample No.	Operator 1	Operator 2	MEAN ($\bar{X}$)	VARIATION $\lvert Xi - \bar{X} \rvert$	VARIABILITY %
1	3.80	3.08	3.44	0.36	10.47
2	<0.11	<0.11	0.11	0	0
3	1.20	0.68	0.94	0.26	27.66
4	2.62	1.60	2.11	0.51	24.17
5	3.76	3.36	3.56	0.2	5.62
6	1.94	1.94	1.94	0	0
7	0.17	0.17	0.17	0	0
8	3.75	4.23	3.99	0.24	6.01
9	0.29	0.14	0.215	0.075	34.88
10	0.04	0.09	0.065	0.025	38.46
11	0.88	0.98	0.93	0.05	5.38
				av.	12.23%

(Reference: T&A 49431)

B)

Sample No.	Operator 1	Operator 2	($\bar{X}$)	$\lvert Xi - \bar{X} \rvert$	%
1	3.12	4.08	3.6	0.48	13.3
2	3.04	3.29	3.17	0.12	3.79
3	3.26	3.25	3.26	0	0
4	4.10	4.10	4.10	0	0
5	3.65	3.87	3.76	0.11	2.93
6	2.74	2.96	2.85	0.11	3.86
7	2.46	2.10	2.28	0.18	7.89
8	2.17	3.69	2.43	1.27	52.26
9	3.42	3.42	3.42	0	0
10	2.28	2.58	2.43	0.15	6.17
11	4.74	2.91	3.58	0.67	18.72
12	3.11	4.14	3.63	0.51	14.05
13	2.79	4.30	3.55	0.75	21.13
				av.	11.08%

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TABLE 2 (continued)

B) TV Screen Viewing

a) (Reference: T&A 49431)

Sample No.	Operator 1	Operator 2	MEAN ($\bar{X}$)	$\lvert X_i - \bar{X} \rvert$	%
1	1.68	2.64	2.16	0.48	22.22
2	3.80	2.53	3.17	0.635	20.06
3	3.91	2.61	3.26	0.65	19.94
4	3.65	3.42	3.54	0.115	3.25
5	3.65	5.24	4.45	0.795	17.87
6	1.25	3.19	2.22	0.97	43.6$
7	2.46	2.28	2.37	0.09	3.80
8	3.26	2.61	2.94	0.325	11.07
9	3.61	3.23	3.42	0.19	5.56
10	2.13	1.67	1.90	0.23	12.10
11	3.28	4.20	3.74	0.46	12.23
12	2.28	3.94	3.11	0.83	26.69
13	1.39	1.77	1.58	0.19	12.03
				av:	14.49%

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TABLE 2 (continued)

B)

b) (Reference: T&A 49930)

Sample No.	Operator 1	Operator 2	MEAN ($\bar{X}$)	$\lvert Xi - \bar{X} \rvert$	%
1	1.32	1.64	1.48	0.16	10.81
3	3.70	3.49	3.595	0.105	29.17
4	0.90	0.77	0.835	0.065	7.78
5	0.91	1.00	0.955	0.045	4.71
6	0.54	0.54	0.54	0	0
7	1.16	1.42	1.29	0.13	10.07
8	0.99	1.16	1.075	0.085	7.91
9	1.17	1.15	1.16	0.01	0.86
10	0.96	1.03	0.995	0.035	3.52
11	1.43	1.18	1.305	0.125	9.58
12	0.22	0.33	0.275	0.055	20.0
18	0.42	0.54	0.48	0.06	12.5
19	0.19	0.25	0.22	0.03	13.64
20	0.02	0.05	0.035	0.015	42.86
21	0.34	0.24	0.029	0.005	17.24
22	0.31	0.26	0.285	0.025	8.77
23	0.42	0.36	0.39	0.03	7.69
24	0.40	0.38	0.39	0.01	2.56
25	0.15	0.20	0.175	0.025	14.29
26	0.28	0.28	0.28	0	0
				av:	11.20%

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TABLE 3

EFFECT ON REPRODUCIBILITY USING THE SAME EQUIPMENT AND THE SAME OPERATOR

(Reference: T&A 49930, Operator: J.Foley)

A) Microscope Viewing

Sample No.	Trial I	Trial II	$\bar{X}$	$\lvert X_i - \bar{X} \rvert$	%
1	2.02	1.58	1.9	0.22	11.58
3	4.95	5.32	5.135	0.185	3.60
4	1.26	1.30	1.28	0.02	1.56
5	1.43	1.00	1.215	0.215	17.70
6	0.83	0.81	0.82	0.01	1.22
7	1.80	1.53	1.67	0.14	8.38
8	1.42	1.46	1.44	0.02	1.39
9	1.55	1.53	1.54	0.01	0.65
10	0.75	0.68	0.715	0.035	4.90
11	1.51	2.07	1.79	0.28	15.64
12	0.27	0.31	0.29	0.02	6.9
18	0.37	0.58	0.475	0.105	22.11
19	0.27	0.29	0.28	0.01	3.58
20	0.04	0.02	0.03	0.01	50.0
21	0.35	0.28	0.33	0.05	15.15
22	0.35	0.29	0.32	0.03	9.37
23	0.48	0.50	0.49	0.09	18.37
24	0.26	0.20	0.23	0.03	13.04
25	0.17	0.12	0.145	0.025	17.24
26	0.20	0.20	0.20	0	0
				av:	8.87%

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TABLE 3 (continued)

EFFECT OF REPRODUCIBILITY USING THE SAME EQUIPMENT AND THE SAME OPERATOR

(Reference: T&A 49930, Operator: J.Foley)

B) TV Screen Viewing

Sample No.	Trial I	Trial II	$\bar{X}$	$\lvert Xi - \bar{X} \rvert$	%
1	1.32	1.73	1.52	0.20	13.16
3	3.70	5.27	4.485	0.785	17.50
4	0.90	0.73	0.815	0.088	10.452
5	0.91	1.18	1.045	0.135	12.92
6	0.54	0.76	0.65	0.11	16.93
7	1.16	1.46	1.31	0.15	11.45
8	0.99	1.16	1.075	0.085	7.91
9	1.17	1.03	1.1	0.07	6.36
10	0.96	0.83	0.895	0.065	7.26
11	1.43	1.77	1.6	0.17	10.63
12	0.22	0.40	0.31	0.09	29.03
18	0.42	0.50	0.46	0.04	8.70
19	0.19	0.29	0.24	0.05	2.08
20	0.02	0.02	0.02	0	0
21	0.34	0.28	0.31	0.03	9.68
22	0.31	0.20	0.255	0.055	21.57
23	0.40	0.36	0.39	0.03	7.69
24	0.40	0.28	0.34	0.06	17.65
25	0.15	0.12	0.135	0.015	11.11
26	0.28	0.33	0.305	0.025	8.20
				av:	12.06%

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TABLE 4

SUMMARIZED RESULTS OF TABLES 1,2 & 3

VARIABLES	CONSTANTS	% VARIABILITY	Ave.
Viewing equipment	Operator	11.19	10.85
Viewing equipment	Operator	13.93	
Viewing equipment	Operator	7.42	
Operator	Viewing Equipment-Microscope	12.23	11.66
Operator	Viewing Equipment-Microscope	11.08	
Operator	Viewing Equipment - TV	14.49	12.85
Operator	Viewing Equipment - TV	11.20	
Repeats, viewing fields	Viewing Equipment, operator - Misc.	8.87	
	Viewing Equipment, operator - TV	12.06	
	Average Total Variability	11.39%	

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TABLE 5

STATISTICAL STUDY OF COUNTING DATA
OF LIBBY SAMPLE AT CAMBRIDGE
(average of 6 countings *)

Sample No.	Mean	Variance	Standard Deviation	Standard Error of Arith. Mean
1	1.64	0.05	0.23	0.095
3	4.51	0.63	0.79	0.324
4	0.99	0.06	0.24	0.099
5	1.06	0.06	0.22	0.089
6	0.67	0.05	0.14	0.057
7	1.45	0.02	0.22	0.088
8	1.19	0.05	0.22	0.088
9	1.24	0.05	0.24	0.097
10	0.88	0.06	0.14	0.06
11	1.03	0.02	0.68	0.216
12	0.31	0.47	0.06	0.025
18	0.49	0.004	0.08	0.032
19	0.24	0.006	0.05	0.021
20	0.03	0.003	0.01	0.005
21	0.29	0.0002	0.06	0.023
22	0.28	0.003	0.05	0.021
23	0.42	0.004	0.06	0.025
24	0.30	0.006	0.08	0.031
25	0.15	0.001	0.03	0.012
26	0.25	0.003	0.05	0.021
		av: .075	0.18	

*Reference (Table 1C, 2Bb, 3A and 3B)

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TABLE 6

COMPARISON OF LIBBY COUNTING DATA
WITH CAMBRIDGE COUNTING DATA

(Reference: T&A 49930)

Sample No.	Libby	Cambridge*	HE**	FGS†
1	3.85	1.64	2.75	
3	8.43	4.51	5.93	5.37
4	2.07	0.99		
5	2.50	1.06	1.62	
6	1.86	0.67		
7	2.82	1.45		
8	2.48	1.19		
9	2.72	1.24		
10	2.70	0.88		
11	2.78	1.03		
12	0.63	0.31		
13	1.87	0.49		
19	0.84	0.24		
20	0.47	0.03		
21	0.76	0.29		
22	0.78	0.28		
23	1.59	0.42		
24	0.93	0.30		
25	0.69	0.15		
26	1.20	0.25		0.30

*The Cambridge data is the mean of 6 countings made by 2 operators, 3 on TV and 3 on microscope. The values were different from those shown in T&A 49930 in which samples 1, 3, 4, 5 were average of 4 countings, and the remainder were average of 2 values; subsequently, more countings were made after the report was issued. Also, value for sample 1 in T&A 49930 should be 1.66 instead of 2.66 (written error).

**HE - Counting made by H. Eschenbach

†FGS - Counting made by F. G. Serafin